VOL. 3 NO. 2 February 1986

COMPUTER DIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

SO YOU'RE GOING TO BUY A MONITOR... A State-Of-The-Art Report

A GERNSBACK PUBLICATION

GRAFEX-32

Build This Hi-Res Graphics Adapter For Your Apple II

SPEAKER ENCLOSURE DESIGN

Let Your Computer Do The Hard Work Part II. The Conclusion

CONTENTS

Vol. 3 No. 2 February 1986

4 So You're Going to Buy A Monitor...
Read this article *before* you go shopping. Armed with this information you can save a lot of time and money. **Herb Friedman**

7 Computer Speaker Enclosure Design
The conclusion of the story begun last month on using your computer to help design enclosures. **Michael and Robert Raleigh**

9 Build The Grafex-32
This hi-res adapter board for your Apple II will make a big difference. Here's the first of a three-part article. **Ray Dahlby**

3 Letters

3 Computer Products

ON THE COVER

Heath's new Model HVM-122A is a 12-inch amber monochrome monitor with excellent definition for 40 or 80 characters. What's more, you can drop the cost of this unit to well-under $100 by assembling it yourself from the kit. You'll find that for most non-color applications, such as word processing, you get better definition with a monochrome monitor. So if you're thinking of going monochrome, or changing to amber, take a long, hard look at this unit, and see page 4.

COMING NEXT MONTH

Look for an intriguing application for the Commodore light pen as a frequency counter. If you've got any questions about printers, you'll surely find an answer in the printer tutorial we'll be running next month. We'll also be offering part two of the three-part article on the Grafex-32, begun in this issue.

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LETTERS

Glitch!

I built the circuit for the Write-Protect Notch By-Pass article in your July, '85 Issue. I found two small errors in Figure 2, the schematic diagram. Capacitor C4's polarity should be reversed so the positive lead connects to pin 2 of IC1. Also, the lead from the junction of IC1 pin 2 and C1, to one side of S2 should be connected to the junction of IC1 pins 1, 8 and C1 instead. With the corrected circuit, I was able to load the program and saved it to a write-protected diskette.
A. F.,
Somerset, Bermuda.

Thank you. We appreciate your help and hope we didn't cause you too much trouble.

CP/M vs MS/DOS

When VCR's became popular, I held off until I could see whether Beta or VHS was going to dominate. I've been holding off on buying a computer for the same reasons, waiting to see if I should go with CP/M or MS/DOS, but there doesn't seem to be any resolution. What should I do?
C. D.,
Reno, NV.

Buy. We now have interface devices that can make any system compatible with any other. So stop denying yourself. Remember when Ralph Kramden refused to buy a TV set because he was waiting for 3-D TV?

Dealer's Choice

I know you select the articles for each issue from those that various authors submit. But if you could have a choice, what would you look for?
S. K.,
Taos, N.M.

Thanks for asking, S.K. Right now we're scrambling for—believe it or not—SHORT articles to fill one or two pages in the magazine! Everything we seem to have now has to be serialized over two or three issues. The subject matter is wide open, but we prefer well-written construction projects.

COMPUTER PRODUCTS

For more details use the free information card inside the back cover

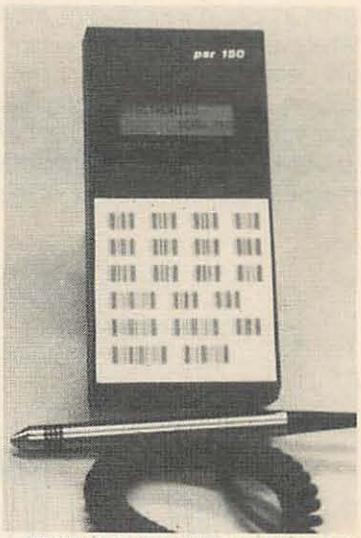
INVOICING SYSTEM, the *Supershipper,* integrates all the elements involved: it is capable of handling customer-account lists, and product and price lists, as well as printing invoices, labels, and C.O.D. tags.

The *Supershipper* is available for the Commodore 64. The program retails for $99.95.—*Progressive Peripherals & Software, Inc.,* 2186 South Holly, Denver, CO 80222.

CIRCLE 11 ON FREE INFORMATION CARD

BAR CODE READER SYSTEM, the model *PSR150,* can be used in either of two basic modes. The on line mode is as a fixed bar code decoder, which will decode bar code information and send it directly to your system. In the storage mode, the unit is a hand-held portable storage device that goes anywhere for collecting data and information at the source, thus eliminating pad and pencil. The stored data can then be transmitted directly to your system, also eliminating the need to key information into the system. Another feature is the scan-pad manual mode. In that mode, individual characters may be scanned from the bar-coded scan pad to form a record. That record can then be sent in the on-line mode or stored in the store mode by scanning the "Enter" bar code on the scan-pad.

The standard unit of the model *PSR150* comes with features such as stainless steel pen, 32-character LCD display, Nicad or alkaline batteries, bar-code keyboard, and serial interface, and is priced at under $500.00. The model *PSR150* is also available with 64KB RAM, at a price of under $1000.00.—*Digitronics Division, Comtec Information Systems, Inc.,* 53 John Street, Cumberland, RI 02864.



CIRCLE 12 ON FREE INFORMATION CARD

SO YOU'RE GOING TO BUY A MONITOR...

What you need to know before you shop.

Herb Friedman

■There are probably as many reasons for buying a monitor as there are for buying a computer. Maybe you just haven't got one, and have been using a television receiver. The kids want the TV back, and it's either buy them a new TV set or go out and do what you should have done in the first place—Buy a monitor!

Or maybe you've got an old green screen jobbie, and want to try one of the newer easy-on-the-eyes amber screen units. Or maybe when you first shucked out the bucks for your computer, you couldn't see the extra cost for a color monitor and settled for a monochrome—for now—with all that Christmas loot burning a hole in your pocket, maybe "now" is "now."

Whatever you've got in mind for that new monitor, you'd better be armed with some facts when you go shopping. You'd better be prepared for the salesman's jargon, you'd better know what he's talking about when he starts throwing technicalities at you, and you'd also better be prepared for some of the "on-the-spot" decisions you're probably going to have to make.

The very-worst thing that can happen if you aren't properly pre-educated, is that you're going to make a wrong purchase. We don't want that to happen, and neither do you. We couldn't possibly send one of our experts along with you on your shopping trip, so we did the next best thing. Here it is:

Selecting a computer monitor used to be easy. Most computer stores stocked only monochrome or color. Today, the terms "monochrome" and "color" are meaningless because there are different models within each category, many are mutually exclusive in that they will not function with signals intended for another kind of monitor.

As a general rule, monochrome monitors present few problems other than the signal connection; except for the IBM-type monochrome monitor all employ what is called a composite video input. "Composite" means the video signal contains both the video and sync signals, such as the NTSC waveform shown in Figure 1a; the same kind of signal used for conventional broadcast Black & White TV. Any TV set or composite TV monitor can be used for a computer as long as it can resolve the required detail. Since a composite

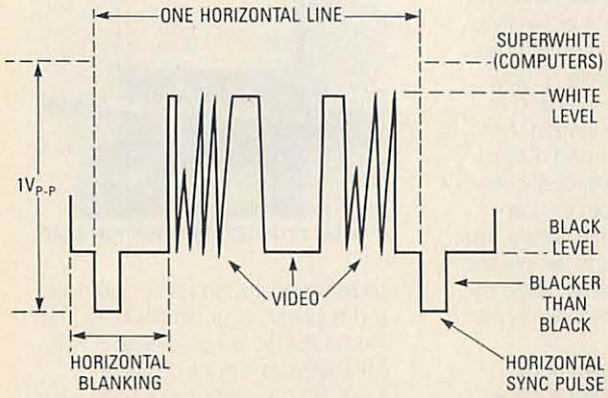


FIG. 1a—THE COMPOSITE VIDEO output from monochrome personal computers uses the same NTSC format used for broadcast TV.

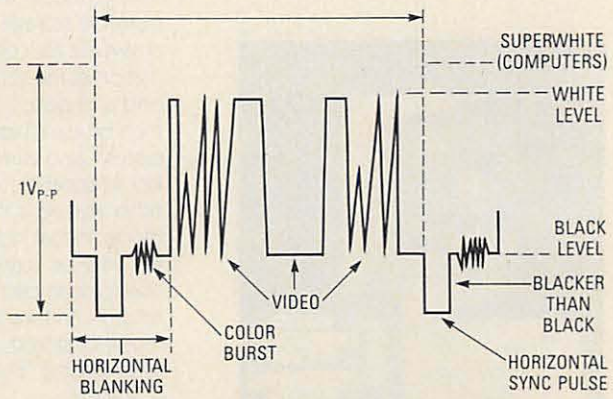


FIG. 1b—COLOR COMPUTERS simply superimpose a color burst on the back porch of the vertical sync. The monitor integrates the color burst with the video signal to create a color display. Without the color burst a color monitor would create a monochrome display.

video signal can be carried on a single shielded wire, the video input connector for those composite monitors specifically intended for personal computers is usually a "phono" jack, though some manufacturers have used unusual connectors which require an expensive "adapter cable." (The more rugged UHF and BNC connectors are generally used on monitors primarily intended for closed circuit TV.)

The resolution of a monochrome monitor is usually not a problem because the frequency response of the monitor serves as an indicator of what to expect. The conventional bandwidth of approximately 6-8 MHZ used for closed circuit TV monitors can resolve up to 40 characters per line, possibly 50 characters. A 60 character line requires about 8-12 MHz, a sharp 80 character line takes from 14 to 22 MHz or greater.

Most important, a composite monochrome monitor can be used for both monochrome and composite color signals. It simply ignores the color burst, which, as shown in Figure 1b is the same as the composite monochrome signal shown in Figure 1a.

Until the introduction of the IBM-PC, composite video was the standard signal for personal computers. One of the few attempts to avoid using conventional composite video (especially for monochrome display) was the Osborne computer. Aftermarket vendors immediately introduced composite adapters because non-composite monitors was an idea whose time had not yet come. At its best it was a hinderence to convenient use of the computer.

It was IBM that really created the use of non-composite monitors for personal computers. When the IBM-PC was first introduced considerable sales effort went into convincing the buyer that the composite color output could not be used for monochrome displays. This, of course, was sheer nonsense, meant to sell an expensive monochrome adapter and a special, expensive monitor. Since no one else was selling "IBM-type" monochrome monitors IBM had the market to themselves because no other monochrome monitor would work with IBM's monochrome adapter signals.

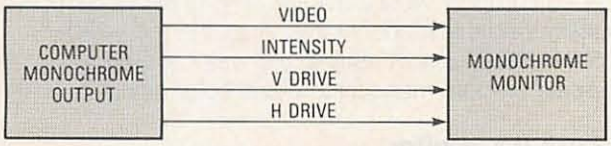


FIG. 2—A COMPUTER WITH an IBM-type monochrome output provides individual TTL signals (non-NTSC) for the video component, intensity, and the vertical and horizontal drive. The monitor integrates the four signals into a screen display.

Figure 2 shows how the IBM-type monochrome computer output differs from conventional single-ended composite video. The multi-terminal IBM-type output connector provides separate TTL signals for video, intensity, and horizontal and vertical drive. The signals are converted into a video display within the monitor. Obviously, the IBM-type monochrome signals cannot be used to drive a conventional composite monitor. But because conventional composite video isn't used it's possible to employ non-NTSC vertical

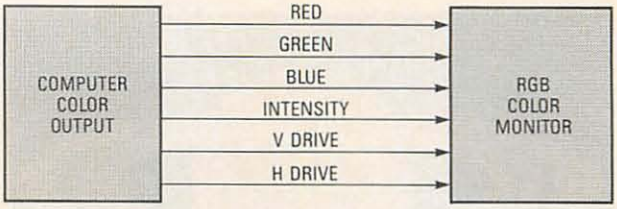


FIG. 3—AN RGB COLOR SIGNAL is also non-NTSC and TTL. Each of the three primary colors is provided as a separate signal along with the intensity and vertical and horizontal drive signals. Like the TTL monochrome monitor, the RGB monitor integrates the separate signals into a complete color display.

and horizontal sweep rates. IBM-type monochrome monitors employ a horizontal sweep of 18 KHz rather than the NTSC rate of 15 KHz, which in combination with a bandwidth of 16MHz results in a display having greater resolution than a conventional monitor.

Color monitors

Color monitors are available in two configurations, known as composite and RGB. In basic terms, the composite produces color displays by processing the composite video and the color burst. (If the color burst is eliminated from the computer's signal the video will be displayed in monochrome on both monochrome and color monitors, for without the color burst from the computer a color monitor cannot create color). As a general rule, almost any hue of any intensity can be displayed by a composite monitor; any limitation on the display of a particular hue is more a function of the computer than the monitor.

Unlike composite video which is an analog signal even if the information it carries is derived digitally, RGB signals are digital representations of the instantaneous color and intensity values of a single picture element. Like the IBM-type monochrome displays, RGB color monitors work with TTL signal levels, only now there are individual digital signals for RED, GREEN, BLUE, INTENSITY, and the vertical and horizontal drive. The signals from the computer, shown in Figure 3, are processed within the RGB monitor to produce a color display capable of the 16 colors shown in Figure 4. Normally, just the three RGB signals can produce the 8 colors indicated with an asterisk; the additional 8 are made possible by integrating the intensity signal with the RGB signals.

RGB COLOR DISPLAY

Basic color	Intensified color
* Black	Dark grey
* Blue	Light blue
* Green	Light green
* Cyan	Light cyan
* Red	Light red
* Magenta	Light magenta
Brown	* Yellow
* White	Intensified (super) white

* Indicates conventional pre IBM-PC basic color rainbow.

FIG. 4—A MODERN RGB MONITOR that is IBM-compatible will produce 16 colors including brown. Before the introduction of the IBM-PC, RGB monitors produced yellow instead of brown, and some RGB monitors could only produce the eight colors indicated with an asterisk ("*").

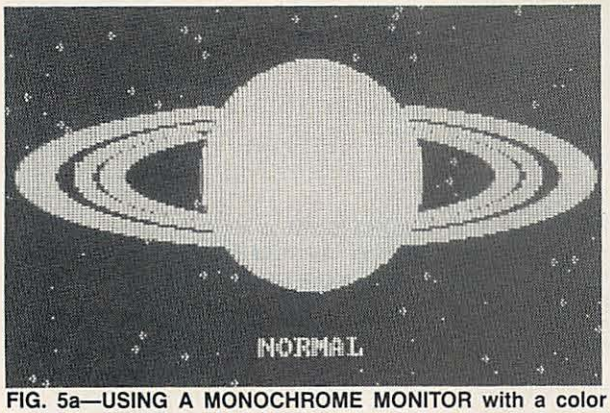


FIG. 5a—USING A MONOCHROME MONITOR with a color signal intended for an RGB monitor usually results in excess "gain" and considerable loss of detail in both the graphics and text characters.

Presently, all conventional RGB monitors create 16 colors from conventional personal computer signals. Unfortunately, some early monitors, a few of which occasionally surface in the surplus market, do not process the intensity signal and provide only 8 colors. It's not that the color table shown in Figure 4 is different from the earlier and conventional RGB colors in that the yellow is not part of the basic 8 colors derived form RED, GREEN and BLUE. In a conventional 8-color rainbow there is no brown: The position occupied by brown in Figure 4 is normally yellow. Unfortunately, although the intensity signal produces lighter versions of seven of the original 8 colors—thereby also producing a legitimate grey and an intense or "super white" (which is actually close to, or equal to the maximum screen brightness)—lighter yellow is still yellow. Also, the lack of brown sharply limits graphic artwork. To make the 16 color rainbow more applicable to "natural"graphics, IBM substituted brown for the basic yellow, and provided yellow in the intensified rainbow. Although brown came into common use with the IBM personal computers, it is now considered "standard" because most personal computer equipment attempts to be IBM-compatible.

Monochrome from RGB

While it is usually possible to use a mononchrome monitor with a composite color output, programs specifically written for an RGB color output often produce little more than "garbage" on a monochrome display even if the monitor's signal source is a composite color video output. For example, in addition to the RGB color output the IBM Color/Graphics Monitor Adapter and its aftermarket clones have a composite video output which can be used to drive both composite color and composite monochrome monitors. If the computer is told to operate in the monochrome mode it will convert a color display to composite video that can be viewed on a monochrome monitor in two shades of monochrome: normal and highlight. If the program is self-booting so that the computer outputs only for RGB the composite video will contain "grainy"characters and missing graphic elements.

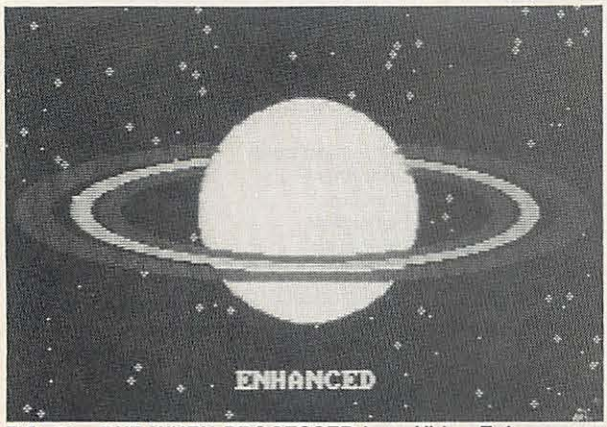


FIG. 5b—BUT WHEN PROCESSED by a Video Enhancer an RGB color signal can look quite good on a monochrome monitor because the device converts each color to an individual shade of grey.

By using a device known as a Video Enhancer (Power-R, Inc., 4016 Interlake N., Seattle, WA 981031) the RGB, intensity and H & V drive signals are converted into an "enhanced" composite monochrome output having each of the 16 colors represented by a discernable shade of grey. The Video Enhancer is actually built in a conventional 9-terminal D-connector, the same kind normally used for the RGB connector. It derives it's power from the power terminal normally provided on a Color/Monitor Adapter's light pen connector. The output cable of the device is terminated in a conventional phono plug, which can be connected to any conventional composite video monitor.

Figure 5 shows how the Video Enhancer recombines the individual RGB picture elements into a monochromatic grey scale display. Figure 5a, which has not been retouched, shows how the "rings of Saturn" from a Color/Graphics Monitor Adapter's color composite output would appear on a monochrome monitor: There is obviously much detail missing from the graphic art, as well as from the text word "NORMAL." Figure 5b shows how the very same display appears on the same monochrome monitor if taken from the RGB output and processed by the Video Enhancer. Notice that the rings of Saturn are now clearly visible in monochrome. Also, the text word "ENHANCED" is now legible, the way it should really appear on both monochrome and color monitors.

Match the monitor

As you can see, not only are the different types of monitors and their signals mutually exclusive, but the software can also determine the kind of monitor needed. For example, while many users prefer a monochrome monitor for word processing (because the image is sharper), much graphics software and software employing graphics intended for color monitors simply doesn't provide a usable display on monochrome monitors, although monochrome software is almost never a problem when used with a color monitor. The best of both worlds when you cannot afford an RGB color monitor is the Video Enhancer because it provides usable displays from both monochrome and color software.◀CD▶

COMPUTER-AIDED DESIGN OF LOUDSPEAKER ENCLOSURES PART II

Michael Raleigh and Robert Raleigh

This article, begun last month, is concluded here.

Figure 8 shows the results of a computer experiment which simulates putting this woofer in a ducted port. The dimensions are provided in the figure. The curve now shows a bump which extends the low-frequency response. The experiment is carried further in Figure 9 which shows the effect of changing the tuning condition of the enclosure by varying the duct length.

On the basis of the results shown in Figure 9 an enclosure was constructed with a .124 cubic meter volume, a .0889 meter port radius, and a.229 meter port length (3.5 inch radius, 9-inch length). The agreement between the computer experiments and the actual experiments was verified by comparing the computed and measured admittances (Figure 10). The measurements were made using the same apparatus, as

FREQ.	POWER	ADMIT.
15	2.31772192E-07	.848189537
20	1.68971018E-06	.0235715462
25	8.61352578E-06	.0434289249
30	3.62626319E-05	.0796287389
35	1.3144318E-04	.12024084
40	3.56205788E-04	.148312467
45	5.63215859E-04	.13413084
50	5.91091327E-04	.0942733156
55	5.53844955E-04	.0583549864
60	5.20822504E-04	.0325508638
65	5.01588831E-04	.0187016634
70	4.93319462E-04	.0215519606
75	4.92573898E-04	.0318286229
80	4.96855005E-04	.0424188525
85	5.0448192E-04	.052132713
90	5.14323853E-04	.0608901319
95	5.25606553E-04	.0687862988
100	5.37789077E-04	.075933387
105	5.50486824E-04	.0824308995
110	5.63422773E-04	.0883621018
115	5.76395798E-04	.09379598
120	5.89259526E-04	.0987899646
125	6.01907806E-04	.103392324
130	6.14264476E-04	.107644055
135	6.26275981E-04	.111580339
140	6.37905941E-04	.11523164
145	6.4913109E-04	.118624556
150	6.59938168E-04	.121782475
155	6.70321592E-04	.124726084
160	6.80281594E-04	.127473777
165	6.89822796E-04	.130041985
170	6.98953111E-04	.132445442
175	7.07682842E-04	.134697403
180	7.16024011E-04	.13680983
185	7.23989816E-04	.138793545
190	7.31594198E-04	.140658362
195	7.3885152E-04	.142413199
200	7.45776308E-04	.144066176
205	7.52383052E-04	.1456247
210	7.58686063E-04	.147095535
215	7.64699346E-04	.148484873
220	7.7043653E-04	.149798383
225	7.759108E-04	.151041271
230	7.81134873E-04	.152218314
235	7.86120948E-04	.153333908
240	7.90880703E-04	.154392102
245	7.95425308E-04	.155396625
250	7.99765393E-04	.15635092

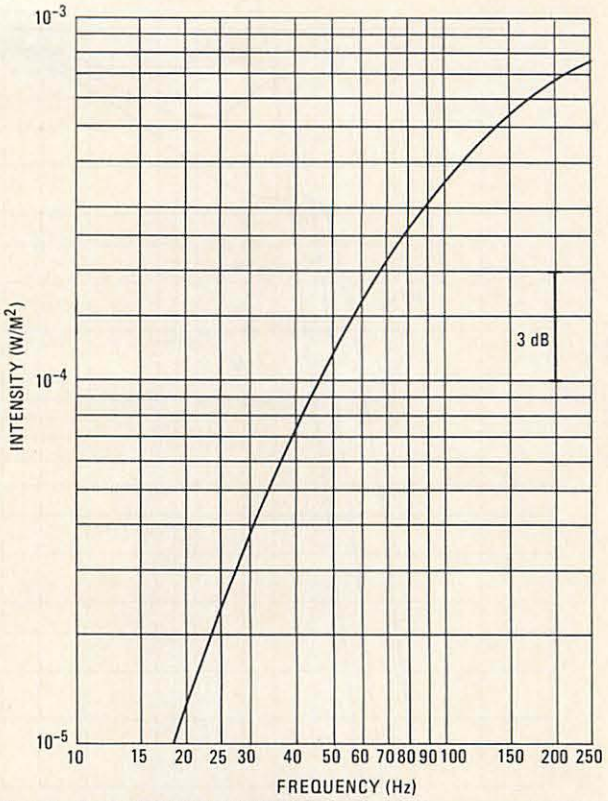


FIG. 7—ACOUSTIC INTENSITY in watts/meter squared versus frequency for a .2 cubic meter infinite baffle enclosure. A 3db difference is indicated for this graph and applies to all subsequent response curves.

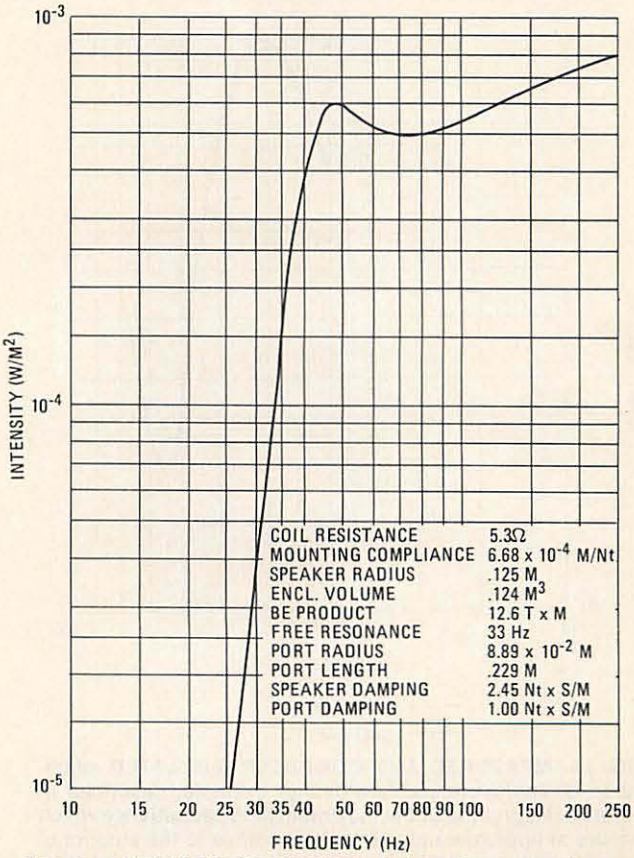

10^{-3}
10^{-4}
10^{-5}
INTENSITY (W/M²)
COIL RESISTANCE 5.3Ω
MOUNTING COMPLIANCE 6.68 x 10^{-4} M/Nt
SPEAKER RADIUS .125 M
ENCL. VOLUME .124 M^3
BE PRODUCT 12.6 T x M
FREE RESONANCE 33 Hz
PORT RADIUS 8.89 x 10^{-2} M
PORT LENGTH .229 M
SPEAKER DAMPING 2.45 Nt x S/M
PORT DAMPING 1.00 Nt x S/M
10 15 20 25 30 35 40 50 60 70 80 90 100 150 200 250
FREQUENCY (Hz)

FIG. 8—COMPUTED RESPONSE of ducted port enclosure constructed in design example. Parameters are listed above.

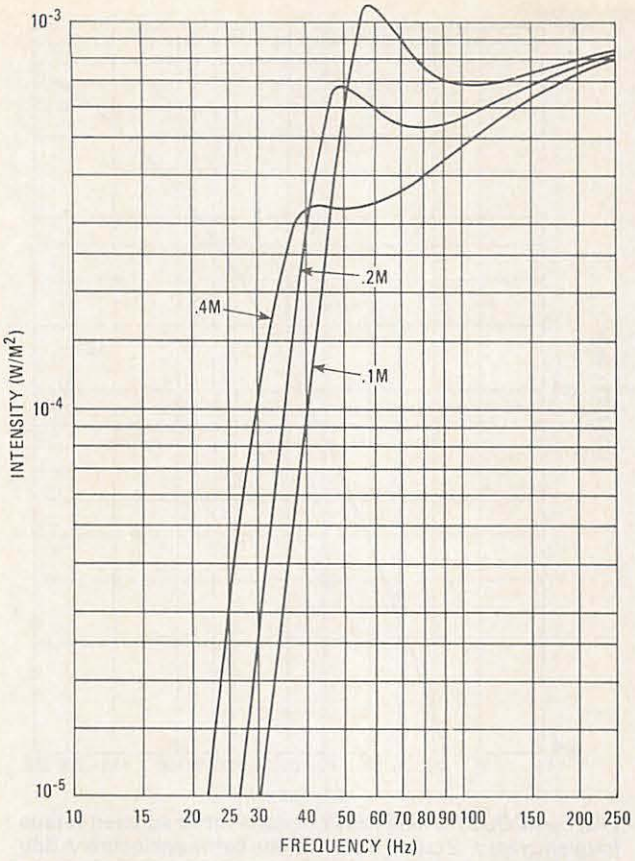


FIG. 9—COMPUTED RESPONSE for design example with various duct lengths. Other parameters same as Figure 8.

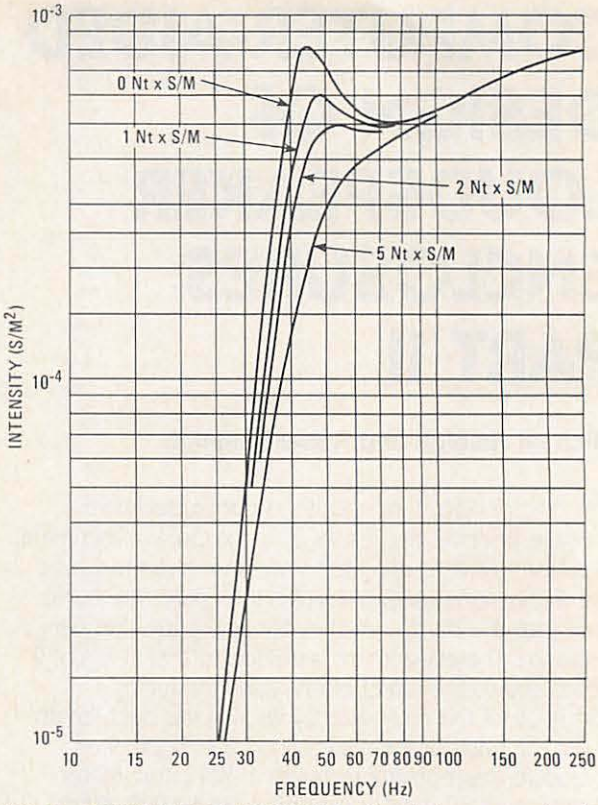


FIG. 11—COMPUTED RESPONSE for the design example with various amounts of damping in the port. Other parameters are as given in Figure 8.

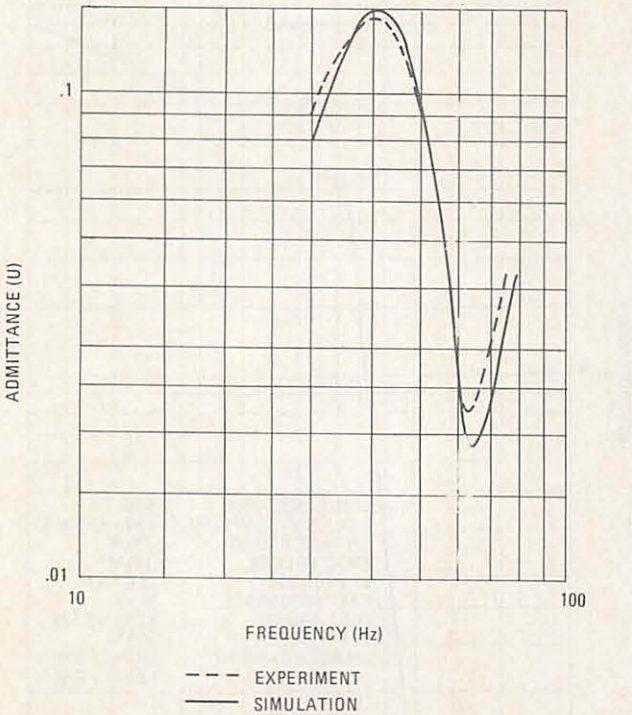


FIG. 10—MEASURED AND COMPUTER SIMULATED admittance of enclosure built as design example, described in Figure 8. Magnitude of the maximum in the admittance which occurs at approximately 40 Hz is sensitive to the amount of damping in the port. Matching measured and simulated maxima provides a means of determining the damping in the port.

shown in Figure 5, but with the woofer now in the enclosure. To achieve best agreement, a small amount of damping must be assumed in the port.

As a final computer experiment, we investigated the effect of adding additional damping to the port (Figure 11). On the basis of these results, it was decided not to increase the port damping. It is our design philosophy that frequency response takes precedence over transient response. We have therefore made our choice of damping based on this steady-state program result.

Infinite baffle enclosures are simulated by assuming a very long, very narrow duct. (.001 meter radius, 1000 meter length). A ported enclosure is simply a ducted port enclosure with a very short duct. In this case, a greater proportion of the effective mass of the duct is due to the motion of air external to the duct. This effect is included in the program however, so that a proper simulation of a ported enclosure results from entering the length of the duct as the thickness of the speaker faceplate. For example, a 1-inch thick faceplate implies a duct length of .00254 meters. If a port or duct is not round in cross section, the radius should be that which gives the same area as the real port or duct.

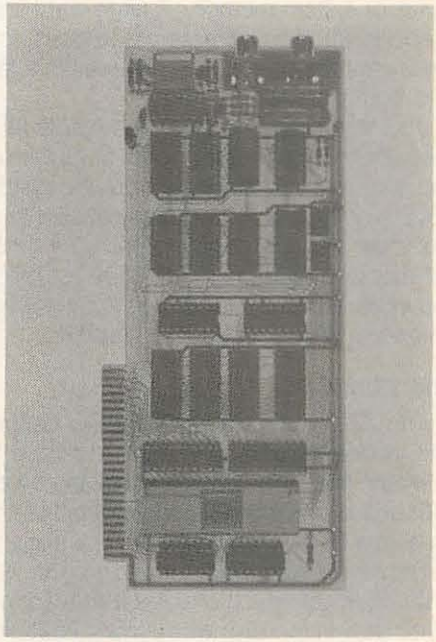
Conclusion

We have shown but a few examples. The reader is invited to systematically investigate the effects of varying each woofer and enclosure parameter. This program also provides an output—the admittance—whereby the match between the program and the actual loudspeaker may be verified.◀Ⓓ▶

BUILD THE GRAFEX-32

PART 1

A 640 by 400 graphics adapter for the Apple II.



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■The Apple II's graphics resolution of 280 by 192 pixels can no longer be considered the "state of the art." The newer Apple *Macintosh* and *Lisa* computers display their bit-mapped images from up to 32K bytes of memory, over four times that used for display on the Apple II.

Recently, the availability of 64K dynamic RAM chips and VLSI graphics controllers at reasonable prices has made it feasible to expand the Apple II's graphics resolution using a simple plug-in circuit board. The Grafex-32 circuit board uses four 16K by 4 bit RAM chips along with a 7220 graphics controller to display 32K bytes of memory as a bit-map of 640 by 400 pixels. The board can be expanded to 128K bytes by plugging in 64K by 4 bit RAM chips and three such boards can be installed in a system to provide the red, green, and blue signals for color graphics displays.

Our design tradeoffs favor circuit simplicity with the option of expansion later, over a complex design incorporating features which might not have been used by everyone. Although the basic circuit consists of just 20 chips, it displays a monochrome resolution of 256,000 pixels on a standard Apple Monitor. Since this baseline performance exceeds the graphics resolution of the Macintosh computer, I decided not to increase the complexity, and thus the cost, of the basic circuit board and thereby provide hardware "hooks" by which the design can be upgraded by those users with higher resolution or color requirements. This design philosophy seems consistent with that of the Apple II itself.

The Apple II

The Apple II/IIe line owes much of its success to the expandability afforded by its expansion slots. In the six or so years that this computer has been on the market, hardware manufacturers have responded to the challenge of filling those slots by developing products to expand the machine and now, with a multitude of add-on cards available, it is surprising to find an area which has not been adequately served.

One such area seems to be the expansion of the Apple II's graphics resolution. Although a few cards were produced to add sprite-oriented graphics and luminance attributes to the Apple II, these did not significantly increase the number of pixels on the screen. Part of this lapse can probably be attributed to the introduction of the I.B.M *PC* which has distracted the focus of third-party hardware manufacturers at a time when VLSI graphics chips and cheap memory make Apple II graphics expansion an easy matter.

The Apple II line can benefit from new graphics technology in other ways than increased screen resolution. The video design used in the Apple II maps the display memory into the 6502 micro-processor's address space in a technique called "memory-mapped video." This was a good choice at the time because it allowed the 6502 full access to the screen memory using all memory reference instructions and addressing modes just as if it were addressing normal system RAM. In fact, if the high resolution screens are not used, the memory space allocated to them can be used for program and data storage. The design of the Apple II limits the graphics resolution for a least two reasons, one being the restricted bandwidth of the home color televisions it was assumed that Apple owners would be using as their display devices. A second reason is limited amount of memory space which can be addressed by the Apple's 6502 microprocessor. This chip has 16 address lines which allows it to address only 65,536 bytes so a memory-mapped video design using half of this precious space just would not have been practical.

Memory-mapped video design is not limited to low resolution graphics as evidenced by the newer Apple *Macintosh* and *Lisa* machines. The 68000 microprocessor used in these computers has a 24-bit address bus and can directly address more than 16M

bytes of system memory. A large graphics RAM mapped into this address space does not represent a significant fraction of the total available for program and data storage.

The answer to improving the Apple II's graphics resolution without using up all of its memory is to keep the graphics RAM separate from the system RAM. The 6502 won't be able to directly access to display RAM but there are new chips optimized for managing large bit-mapped memories. The 6502 actually benefits from the increased program available by not having part of its system RAM allocated to graphics.

The 7220 GDC

The 7220 GDC (*G*raphics *D*isplay *C*ontroller) from NEC is designed to handle the repetitive tasks required in figure, line, and character drawing on a raster scan CRT. Unlike previous CRT controller chips such as the Motorola 6845 whose tasks were limited to display refresh and video synchronization. The 7220 has an instruction set which enables it to read, modify, and write data in the display memory. Positioned between the system microprocessor bus and the display memory, it responds to instructions passed to it and draws figures without processor intervention. Since the GDC can handle much of the repetitive pixel drawing and modification tasks, the bandwidth requirement of the microprocessor/display memory path is greatly reduced. Most of the data sent from the microprocessor during vector and geometric shape drawing will be in the form of commands and parameters sent directly to the GDC which then interprets them into pixel-level operations to be carried out over the high-bandwidth GDC/display memory path. Its pipelined architecture is optimized for such graphics manipulation and it handles these tasks with great speed. For example, a 7220 running at a clock frequency of 5 Mhz can draw a figure at the rate of 800 ns per pixel. This speed is independent of the type of figure being drawn and is much faster than a general purpose microprocessor, such as the 6502, handling the same task.

The 7220 was chosen for this design because its 8 bit uP data bus interfaces nicely with the Apple's 8 bit 6502 and its 16 bit video data bus and 18 bit video address bus allows it to accomodate large bit-mapped display memories without impinging on the limited 16 bit addressing of the 6502. It also handles dynamic RAM refresh and video sync generation. This part is housed in a 40-pin ceramic package and is fabricated in 3um NMOS. It encompasses the equivalent of over 13,000 transistors.

The display memory

The 7220 requires its display memory to be organized in 16-bit words. The most common 64K dynamic RAM chips, such as the 4164, are organized as 65,536 locations of 1 bit each so 16 of these parts are

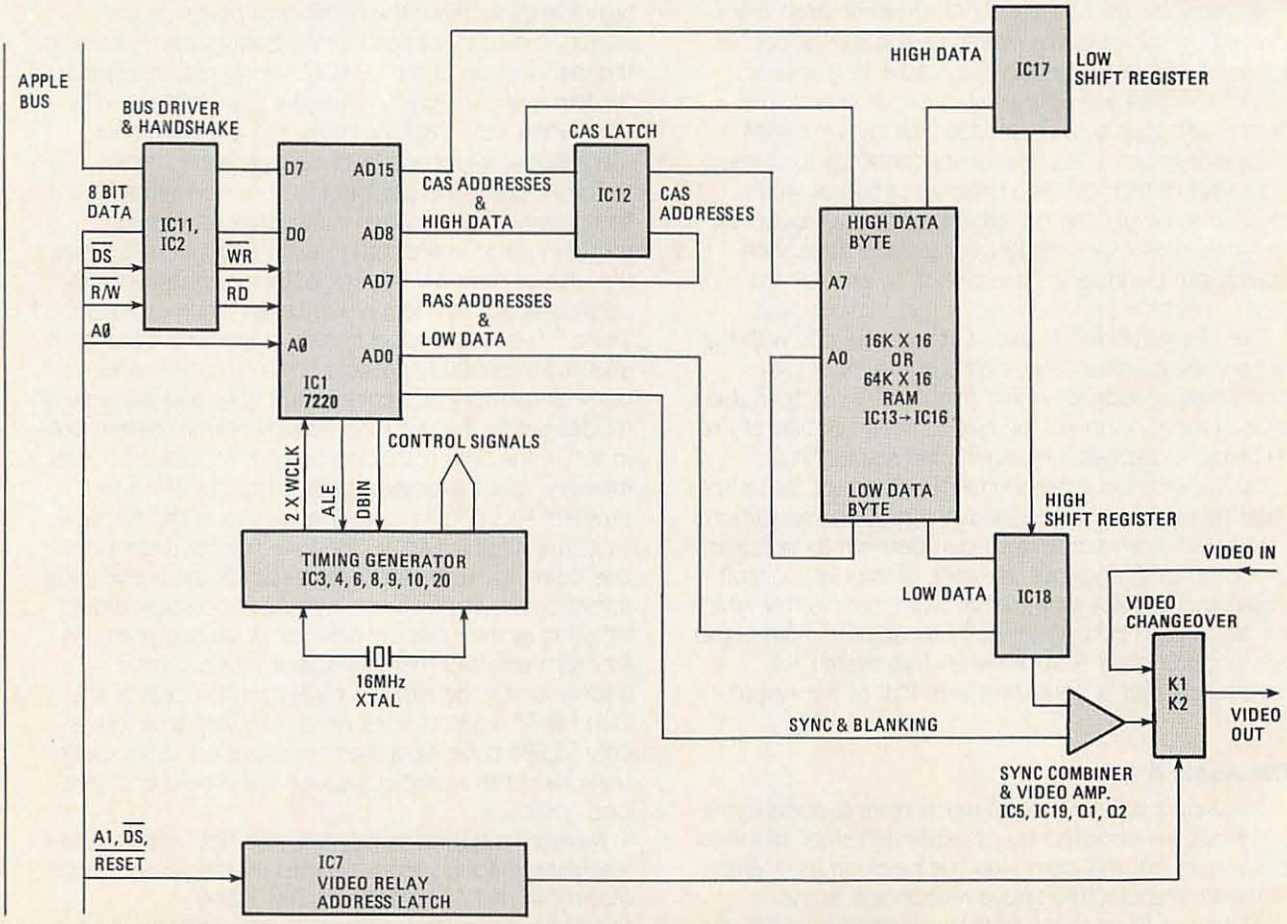

FIG. 1—BLOCK DIAGRAM OF THE GRAFEX-32 should be used along with the schematic diagram to help understand the theory of operation.

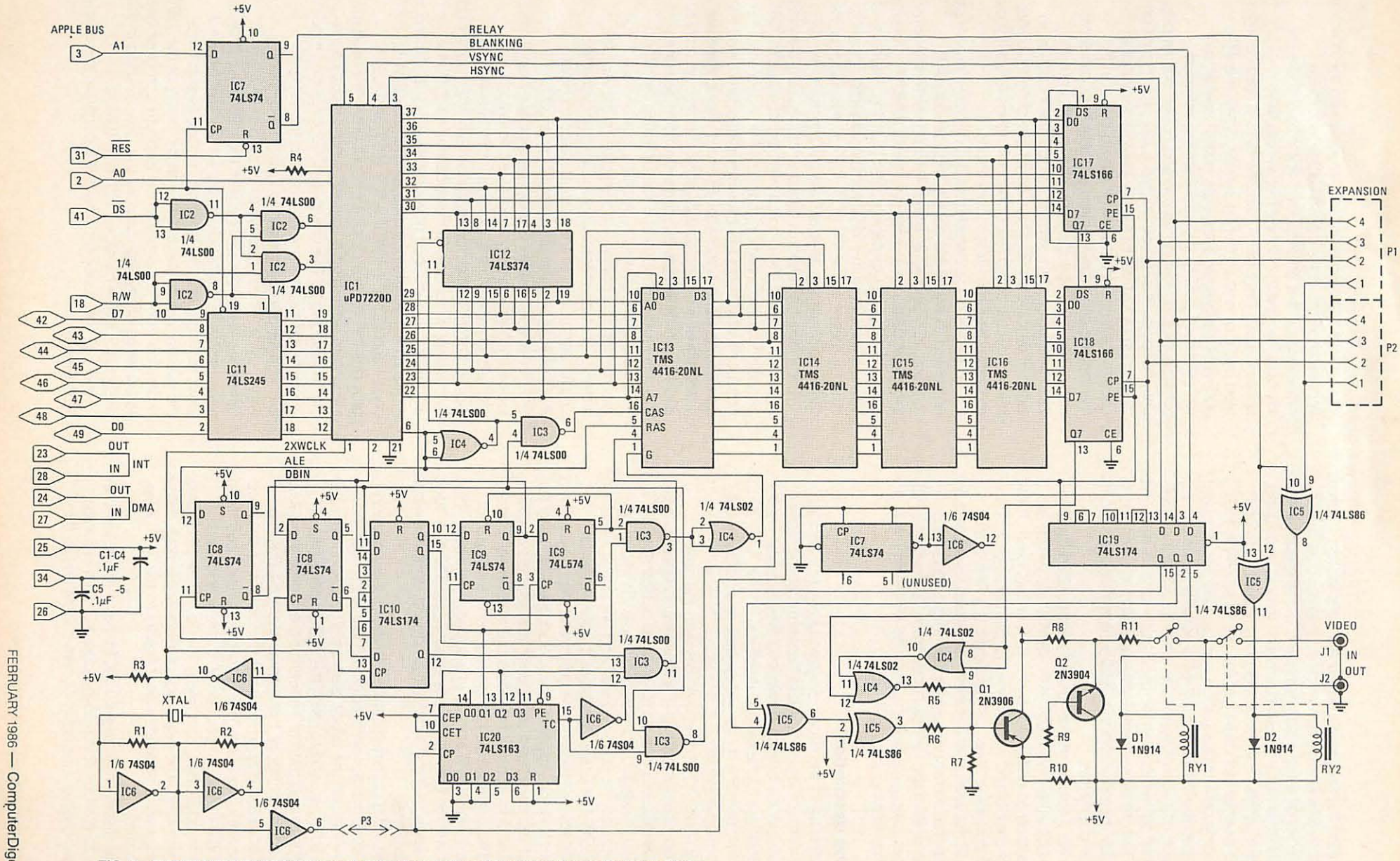

FIG. 2—SCHEMATIC DIAGRAM is not difficult to follow if you take it step-by-step. Refer to this while reading the text and you'll have an almost-immediate grasp of what is going on from input through output!

required to assemble a 16-bit memory system. There is another 64K RAM chip which is organized as 16,384 locations of 4 bits each. This part, designated the 4416, is available from Texas Instruments, Inmos, and Fujitsu, among others. The 16 bit data bus requirement of a 7220 can be met using just four of these chips, thus reducing power dissipation and printed circuit board complexity. The use of the 4416 actually helps to reduce chip count further as it has a separate output enable pin which can be used to tri-state its data lines. This feature allows very tight coupling between the display memory and the 7220 which helps to simplify P.C. layout further.

Texas Instruments has recently announced the 4464 and NEC, the 41254, dynamic RAM chips which are organized as 65,536 locations of four bits each. These parts are housed in the same 18-pin package as the 4416 and allow easy system upgrades. The Grafex circuit, for example, has been designed to address the additional memory provided by these parts and expansion of the Grafex circuit from 32 Kbytes to 128 Kbytes is accomplished simply by replacing the 4 display RAM chips.

Circuit description

Referring to the block diagram of Figure 1 and the schematic of Figure 2, it can be seen that the Grafex circuit can be broken down into five sections. These sections are a) the uP bus interface, b) the 7220, c) the display memory, d) the video output circuitry and e) the timing generator.

The 7220, IC1, communicates with the host microprocessor over its eight bidirectional data lines. IC11, A 74LS245 is used to provide buffering and IC2, a 74LS00 is used to convert the Apple's R/W and DS signals into the 8080-type RD and WR signals used by the 7220. The Grafex circuit uses four of the 16 addresses assigned to the peripheral slot in which it is installed in the Apple II. These addresses are used to select the command and parameter registers of the 7220 and to control the video changeover relay latch, IC7. The addresses and their functions are listed in Table 1 which will appear in a subsequent issue. The reset line on the Apple bus is connected to this video relay latch to force a default on power up to the Apple video signal.

The 7220 communicates with the display memory over its 16 multiplexed address/data lines, labelled AD0-AD15 on the block diagram. The CAS latch, IC12, a 74LS374, is used to latch the high order 8 bits of addresses and then to sequence them onto the 8 RAS/CAS address lines of the display memory. This is a tight-coupled design from the standpoint of data and address multiplexing. The low address/data path from the 7220 carries, in sequence, the row addresses, column addresses, and finally, the low byte of display memory data. The high byte of display memory data is carried over a separate path directly to the 7220 AD8-AD15 pins.

The display memory, IC13-IC16, has a multiplexed 8-bit address bus and a 16-bit data I/O with separate output enable. Like other dynamic RAM arrays, the eight row address bits are first strobed into the on-chip latches, then the eight column address bits are presented on the address lines and finally, these are strobed into the memory. After access time specifications have been met, the data is read during a read cycle or written during a write cycle. The 4416 and 4464 parts have a separate output enable pin which allows data to be read from the selected address location but not presented on the output pins until needed. This "G" pin allows a fast (40 ns) turn-on of the output buffers to supply data to the external circuit when needed later in the read cycle. In this manner, the eight row/column address lines can serve also as the low 8-bit data corridor to and from the 7220 and video shift register without the need for an external tri-state buffer. This kind of coupling facilitates printed circuit board layout and improves reliability by reducing the circuit inter-connections.

The 16 bits of data read from the display memory are presented to two 8-bit parallel in/serial out, shift registers, IC17 and IC18. These 74LS166 shifters serialize the 16-bit data into a video bit stream which is clocked at the 16 MHz dot-clock rate. The blanking, Hsync, and Vsync signals from the 7220 are brought into line with data by means of the 74LS174, IC19. It is loaded by the same load/shift signal as are the shift registers.

The video-bit stream is gated with the 7220 blanking signal by IC4 and then mixed with the composite sync provided by exclusive-or gate IC5. The video amplifier, consisting of Q1 and Q2 provides a standard 1 volt P-P composite video signal into 75 ohms. This composite video signal is routed to the video changeover relay, K1 and K2, which selects either the Grafex video or an external input as the source for the video monitor. When the Grafex board is installed in an Apple II, the external input is normally connected to the Apple's video output connector and the changeover relays output connected to the system video monitor. Alternatively, two monitors could be used to simultaneously display Grafex and Apple video. The video changeover relay is software actuated and defaults on reset to the external input, allowing the Apple system to be operated normally after power up. In this way, unless the Grafex board is specifically addressed, a user need never be aware of its existence.

The timing generator, comprised of the 16 MHz crystal and IC3, IC4, IC6, IC8, IC9, IC10, and IC20 provides the various clock and control signals used in the system. All timing is derived synchronously from the 16 MHz clock. The timing generator has two modes of operation depending on whether the 7220 is executing a display cycle or a RMW, (read, modify, write), cycle. These two types of cycles are differentiated by the DBIN pin of the 7220. The 7220, in turn, uses as its master clock, a 2 MHz signal labelled 2Xwc1k. This clock, as its name implies, runs at twice the display word rate and all internal timing of the 7220 is derived from this signal since 16 pixels comprise one 16 bit word of display memory, the 2Xwc1k used in this design is 2 x 16 x 65 ns = 500 ns or 2 MHz.

That's all the space for now. We'll continue this article next month.

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